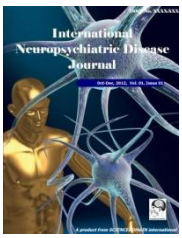

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Assessment of Cognitive Functions, Psychomotor Performance and Attention Deficit Hyperactivity Disorders among Students with Dyslexia

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Authors' contributions

This work was carried out in collaboration between both authors. Author HSH designed the study and wrote the protocol. Author GAS preformed the statistical analysis, managed the literature search, and wrote the first draft of the manuscript with assistance from author HSH. Both authors read and approved the final manuscript.

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ABSTRACT

Aim: The present study presented as a comparison of the cognitive functions, psychomotor performance and attention deficit hyperactivity disorders between dyslexic and control students.
Method: This was a randomized study. The participants were 33 dyslexic students and 34 age, gender, and IQ-matched control students. The major evaluation tools included were Stanford Binet fourth edition for cognitive function, Quick neurological screening scale for learning disabilities, Behavioral Characteristics Rating Scales for Learning Disabilities, three Arabic standardized scales for reading and comprehension and two scales for attention deficit hyperactivity disorders (ADHD).
Results: Comparisons of the 2 groups of students revealed that significantly impairment of some cognitive functions as verbal reasoning, abstract visual reasoning, short term memory and intelligent quotient. Also, impairment of psychomotor performance and higher scores of ADHD were detected among dyslexic group than control group.
Conclusion: Association between dyslexia and ADHD are accompanied with more deterioration in some cognitive functions and psychomotor performance.

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THIS WORK ADDED

- Impairment of cognitive functions and psychomotor performance among dyslexic group.
- Higher scores of ADHD among dyslexic group than control group.
- Dyslexia leaded to more deterioration in cognitive functions, psychomotor performance and ADHD.

Keywords: Dyslexia; cognitive function; psychomotor performance; ADHD.

1. INTRODUCTION

Dyslexia is the most common and most important neurobehavioral kind of reading disability, characterized by difficulty in word decoding, low ability in phonological processing skills and different problems in various forms of written language. In most cases, these problems coexist with the presence of unexpectedly high cognitive abilities like intelligence and academic achievement [1]. Dyslexia is described as a specific deficit in the acquisition of reading (especially word recognition and decoding). Prevalence rates for academic failure in these domains show wide variation, depending on the definitional criteria [2].

Much of the subsequent research on reading and spelling difficulties can be characterized as aiming to identify whether there are additional deficits beyond the documented problems of phonological processing whether, these additional deficits are required to describe the problems of children with dyslexia [2,3]. Examples of these include theories concerning possible perceptual–motor automaticity, visual-perceptual deficits, verbal memory, ADHD and rapid naming deficits [2].

Although, it is clear that the correlation between cognitive function and dyslexia is substantial, it is also clear that the residual variance in word reading after controlling for intelligent questions is considerable and is largely of genetic origin for both children and adults within generally literate populations [4].

Attention-deficit/hyperactivity disorder (ADHD) characterized by developmentally inappropriate and disabling levels of inattentiveness and/or hyperactivity/ impulsivity, is often accompanied by associated learning problems as dyslexia and there was co-morbidity between them [5,6]. A high degree of co-morbidity has been reported between ADHD and dyslexia/reading disorders, it occurs in between 12% and 24% of those with dyslexia [7].

This research activity has centered on the nature and existence of these additional deficits and their relationship to dyslexia.

Aim of the study: This study designed to assess cognitive functions, psychomotor performance and ADHD among students with or without dyslexia.

2. METHODS

This study was approved by the ethical committee of the faculty of medicine and faculty of Art, Assiut University, Egypt. Written approval consent was obtained from the higher authority in Ministry of education in Assiut city to carry out the study. Interviews with the head manager of the school and teachers of the classrooms during the fieldwork had been

done to explain the aim of the study for them. Then we explained that to all students. Written consent was taken from all students shared in this study.

2.1 Study Design

This study was a cross-sectional study, carried out to analyze cognitive functions, psychomotor performance and ADHD among full-time students attending the Alweledia preparatory school for girls at Assiut city during the academic year of first class. Assiut city is the largest town in Upper Egypt and lies about 234 miles south of Cairo. The choice of those students was randomly included all students accept to participate. We included about 50% of all students in that school.

2.2 Participants

We surveyed 200 students from all first class of the preparatory school for girls in Assuit governorate. The students were included in this study were selected randomly by using systemic random sample method. Thirty three students were diagnosed with dyslexia. Both dyslexic and control students were recruited from same classrooms in these schools. The control students were 34 normal students age-, IQ-, and gender-matched to dyslexic group. Exclusion criteria were any neurological (i.e., epilepsy, primary headache, neuromuscular disorders) or psychiatric (depression, conduct disorder) symptoms; mental retardation; hearing or vision problem; a language impairment and/or phono-articulatory problem; obesity as it may affect the psychomotor performance of child, and/or the taking of an anticonvulsant or psychoactive drug. The all Participants were chosen as they had intelligence quotient above 89in two groups according to the Stanfored-Binet Test (fourth edition) [8,9].

2.3 Measures

1- **Stanford–binet test (fourth edition):** All participants (patients and controls) underwent assessment by the Arabic version [9] of the Stanford–Binet test (fourth edition) [8], a standardized and well-validated psychometric testing used to assess memory, attention, language, and concentration. This test is characterized by its relevance to daily living activities in a population of children. The Stanford–Binet test consists of vocabulary, comprehension, verbal relations test, abstract visual reasoning test, quantitative reasoning test, memory for sentences test, bead memory test, and intelligent quotient. The evaluation was performed by a qualified clinical child psychologist.

2- **Quick neurological screening test (QNST):** The Quick Neurological Screening Test (QNST) is a brief screening instrument which purports to identify children having, or likely to develop, learning difficulties in the regular classroom. The development of the QNST is compatible with a model of learning disabilities which invokes the construct of minimal cerebral dysfunction [10]. All Participants applied to standardized and validated Arabic version. Quick Neurological Screen and his relation to learning consist of 15 subtests (Hand Skill Test-Figure Recognition and Production Test- Pair Form Recognition Test-Eye Tracking Test-Sound Pattern Test- Finger to Noise Test-Thumb and Finger Circle Test- Double Simultaneous of Hand and Cheek Test-Rapidly Reversing Repetitive Hand Movements Test- Arm and Leg Extension Test-Tandem and Walk Test- Stand on one leg Test-Skip Test-Behavioral Test-Irregularities Test). The normal scores ranged between 1-24 score, while abnormal scores ranged from 25 and over [11].

3- Behavioral Characteristics Rating Scales for Learning Disabilities Children (BCRSLDC). That scales were standardized and validated Arabic version that used to diagnose learning disabilities from assessment the behavior's of the students from the teachers and parents of students [12].

4- Oral and Comprehension Reading Tests. All Participants took a standardized and validated Arabic version that used to diagnose dyslexia from reading words and sentences using high pitched voice who obtains high score in reading are dyslexia, while in comprehension who obtained low score were dyslexia [13,14].

5- Trail Making Test is a neuropsychological test of visual attention and task switching. It consists of two parts in which the subject is instructed to connect a set of 25 dots as fast as possible while still maintaining accuracy [15]. It can provide information about visual search speed, scanning, speed of processing, mental flexibility, as well as executive functioning [15]. It was used to assess for perceptual, attention and psychomotor performance. The task requires a subject to 'connect-the-dots' of 25 consecutive targets on a sheet of paper or computer screen. There are two parts in the test: A, in which the targets are all numbers (1,2,3 etc.)and the test taker needs to connect them in sequential order, and B, in which the subject alternates between numbers and letters (1, A, 2, B etc.) [16]. If the subject makes an error, the test administrator is to correct them before the subject moves on to the next dot [16].

The goal of the test is for the subject to finish the part A and part B as quickly as possible, the time taken to complete the test is used as the primary performance metric. Error rate is not recorded in the paper and pencil version of the test, however, it is assumed that if errors are made it will be reflected in the completion time [17]. Test B, in which the subject alternates between numbers and letters, is used to examine executive functioning [17]. Part A is used primarily to examine cognitive processing speed.

6- Tapping Machine was designed that all participants were tapping the key in machine using right hand for one minutes and left hand for one minute other. Then we computed the score from a number of tapping on register machine [18].

7- **Scales used to assess ADHD:** We use standardized and validated Children's Attention and Adjustment Survey-School form (CASS-S) [19]. We used this Arabic scale for all students included in this study (200 students), to pick up all suspicious cases with ADHD. This test was applied by the researcher with the help of teachers of the students. The suspicious cases with ADHD were 50 children. Then we applied Children's Attention and Adjustment Survey-House form (CAAS-H) [19] with the parents of these students. This scale was applied for all suspicious students (50 students) this test was applied by the researcher with the help of the parents of the students. All the parents of these students agreed to continue their participation with compliance rate of 100%, Then we applied DSM-IV diagnostic criteria for ADHD [20]We used the diagnostic criteria for final diagnosis [21].

2.4 Procedures

All the tasks were administered individually in the study. After an initial session during which participants and their parents were informed about the objectives of the study, the children performed Stanfored-Binet intelligence test (fourth edition) and scales for ADHD (this session are lasting approximately from 90-120 minutes. In the second session used tests for

diagnose dyslexia that are content of Quick Neurological Screening Test (QNST) and Behavioral Characteristics Rating Scales for Learning Disabilities Children (BCRSLDC) and test for oral and comprehension reading, this session lasting approximately 30 minutes. Finally in the third session all participants measures of psychomotor performance using tapping machine and trail making test, this session lasting approximately 15 minutes. The second and third session were done in the second day after acceptance of parents to continue. Dyslexic group was diagnosed according to the high scores on Quick Neurological Screening Test (QNST) [11], Behavioral Characteristics Rating Scales for Learning Disabilities Children (BCRSLDC) [12], and the high scores on oral(reading scales) and the low scores on comprehension tests [13,14].

2.5 Statistical Analysis

Data obtained from different studies were fed into an IBM compatible computer. Then the computer software package SPSS for Windows (Version 16) was used to do the data analysis. Descriptive statistics (mean±standard deviation, frequencies and percentages) were used. Statistical comparison using independent samples Student's t-test was applied to compare mean values of the studied groups. A series of Pearson correlations coefficient were used to examine the relation between QNST and different dyslexic scales, also the impact of dyslexia on cognitive Functions, psychomotor performance and ADHD. Probabilities less than 0.05 were considered statistically significant.

3. RESULTS

The entire studied groups were females and there was no significant difference in age of both groups, the mean of age of control group was 13.12±0.48 and among dyslexic group was 13.03±0.17. Other characteristics data were illustrated in Table 1. Some cognitive functions as verbal reasoning, abstract visual reasoning, short term memory and intelligent quotient were significantly impaired among dyslexic group than control group. As regard other data as psychomotor performance and ADHD scores were illustrated in Table 2. Significant positive correlation between QNSS and Reading scales were detected in this study. While negative correlation with comprehension was illustrated in Table 3. To examine the effect of dyslexia upon the cognitive functions, psychomotor performance and ADHD, serious of Pearson correlation was done. In which, increased dyslexic symptoms leaded to more deterioration in cognitive functions, psychomotor performance and ADHD as in Table 4.

Table 1. Demographic and characteristics data of studied groups

	Control N=34	Dyslexia group N=33	P value
Age	13.12±0.48	13.03±0.17	0.327
Sex(females)	34(100%)	33(100%)	-
Quick neurological screening	15.17±6.59	33.78±7.17	0.000
BCRSLDC	76.23±26.13	138.9±28.11	0.000
Reading scale (Hassn Shehata)	8.67±4.3	33.76±16.25	0.000
Comprehension	18.78±3.89	10.78±4.51	0.000
Reading scale (Ahmed Awad)	11.53±6.36	58.48±36.18	0.000
ADHD positive cases	0	11(33.3%)	-

Data were described as mean±standard deviation or as number (percentage /100%); ADHD: Attention deficit hyperactivity disorder according to DSM-IV.

Table 2. Cognitive functions, psychomotor and ADHD among studied groups

	Control N=34	Dyslaxia group N=33	P value
Verbal reasoning(VR)	102.18±15.76	94.78±10.64	0.028
Abstract visual reasoning (AVR)	105.18±17.78	97.39±12.34	0.042
Quantitative reasoning(QR)	109.91±17.81	104.55±10.69	0.141
Short term memory(STR)	112.53±32.03	99.09±11.84	0.027
Intelligent quotient	106.2±13.9	98.42±8.17	0.007
Tapping	242.97±48.88	232.12±63.71	0.436
Trial making test	182.47±45.86	221.82±66.11	0.006
ADHD (home form)	12.32±3.71	14.76±4.79	0.024
ADHD (school form)	13.65±4.56	17.39±6.43	0.008
Quick neurological screening	15.17±6.59	33.78±7.17	0.000
Behavioral scale	76.23±26.13	138.9±28.11	0.000
Reading scale by Hassn Shehata	8.67±4.3	33.76±16.25	0.000
Comprehension	18.78±3.89	10.78±4.51	0.000
Reading by Ahmed awad	11.53±6.36	58.48±36.18	0.000

Data were described as mean±standard deviation

Table 3. The relation between QNSS and learning disability

	QNSS
BCRSLDC	0.621(0.000)
Reading scale by Hassn Shehata	0.577(0.000)
Comprehension	-0.611(0.000)
Reading by Ahmed awad	0.565(0.000)

BCRSLDC: Behavioral characteristics rating scales for learning disabilities children; QNST: Quick neurological screening test

Table 4. The effect of dyslexia upon cognitive function, psychomotor and ADHD

	QNSS	BCRSLDC	Reading hs	Reading AA	Comprehension
Intelligent quotient	-0.409(0.001)	-0.363(0.003)	-0.341(0.005)	-0.284(0.024)	0.505(0.000)
verbal reasoning (VR)	-0.225(0.067)	-0.102(0.41)	-0.311(0.010)	-0.238(0.052)	0.237(0.053)
Abstract visual reasoning (AVR)	-0.320 (0.008)	-0.348(0.004)	-0.213(0.083)	-0.169(0.17)	0.416(0.000)
Quantitative reasoning(QR)	-0.274 (0.025)	-0.265(0.030)	-0.188(0.122)	-0.150(0.226)	0.383(0.001)
Short term memory(STR)	-0.332 (0.006)	-0.249(0.042)	-0.257(0.036)	-0.195(0.114)	0.239(0.052)
Tapping	-0.312(0.010)	-0.09(0.471)	0.027(0.829)	0.011(0.929)	0.091(0.462)
Trail making	0.361(0.003)	0.271(0.026)	0.31(0.011)	0.256(0.036)	-0.333(0.006)
ADHD (home form)	0.332(0.006)	0.334(0.006)	0.288(0.018)	0.276(0.024)	-0.387(0.001)
ADHD (school form)	0.320 (0.008)	0.397(0.001)	0.281(0.021)	0.275(0.024)	-0.377(0.002)

Data were described as r (P value) according to Pearson correlation was significant at the 0.05 level (two tailed)
NB: BCRSLDC: Behavioral characteristics rating scales for learning disabilities children; QNST: quick neurological screening test

4. DISCUSSION

It is important to investigate the interrelationships between cognitive functions, psychomotor performance and ADHD with dyslexia. These factors should relate to one another in a way that is consistent with their purpose. Several previous studies have evaluated the importance of inhibition in control and dyslexic students. However, the results of these studies were inconsistent [2,22,23].

In the present study, there were significant impairment in verbal reasoning, abstract visual reasoning, short term memory and intelligent quotient among dyslexic group than matched control group. In addition, more affection in dyslexia items will associate with more impairment in cognitive functions as in Tables 2 and 4.

Keat and Ismail reported the cognitive impairment of simultaneous processing is considered as major factor upon the difficulties of reading among the subjects. Furthermore, they reported that cognitive processes relevant to reading comprehension specifically, phonological processing, verbal working, memory and syntactic awareness can explain reading comprehension performance [24]. Alarcon and De Fries indicated that the correlation between the reading and cognitive factors in the probands should be attenuated. Although the phonotypic correlations between reading performance and general cognitive ability between reading disability and normal are both substantial [25]. Furthermore, Wagne et al(2012) indicated that there are cognitive inhibition in students with dyslexia compare with students normal, wherever The dyslexic students performed worst in word inhibition and their performances in graph inhibition were worse than those of normal students [26]. This finding supports the multiple-deficit hypothesis suggested by Ho et al. that more cognitive deficits may lead to more problems in reading and spelling [27].

The present study exhibited there is no significant difference between two groups in quantitative reasoning one of Stanford-Binet scale fourth edition subtests. That finding was in agreement with the study of landerl et al., who reported that dyslexic children tend to be less advanced in their progress from logarithmic to liner number representations [2].

Another question of the present research addressed the role of short term memory upon dyslexic children as affect on word reading and comprehension. In our study, there was significant decline of short term memory among dyslexic group than control group.

As regard psychomotor as trail making and tapping tests performance in the present study, there are no significant differences between two groups in tapping machine. But there was significant worsening in trial making test among dyslexic group than normal group as prolonged the time needed to connect the circles.

Language disorders are frequently associated with movement difficulties it has been suggested that a common neurological risk factor might under both development language disorder and developmental co-ordination disorder. So, an adequate language is a prerequisite for progress in any area of science, including movement science [28]. Also, the cerebellar theory of dyslexia proposes that cerebellar dysfunction could lead to the myriad of symptoms seen in dyslexic individuals, both in literacy and non-literacy domains. The cerebellum is crucial to the fluent performance of motor skills. Stoodley and his colleague studied the performance of 28 dyslexic compared to 26 control adults on rapid pointing and balancing measures, tasks which are thought to reflect cerebellar function, was investigated. They reported no significant differences between the dyslexic and control participants were

found on the balancing tasks or when the speed and accuracy of pointing were analyzed separately. However, when the speed and accuracy of pointing were combined, the dyslexic participants showed poorer performance than the controls (p=0.045). Furthermore, there were significant relationships between performance on the pointing task and literacy skills, and regression analysis showed that the error and speed of pointing contributed significantly to the variance in literacy skill [29].

That randomized, non-referred samples of girls with ADHD and dyslexia are of critical importance to increase our understanding of the natural history of the co morbidity between ADHD and dyslexia. The core of this study is the sample of carefully defined, research identified ADHD and dyslexia incidence cases. In this study the prevalence of ADHD among dyslexic student was 33%. That higher prevalence could be returned to high association and comorbidity between two disorders [5]. In our study, there were significant higher ADHD symptoms among dyslexic group than control. In addition, scores of dyslexia scales significant correlated with ADHD scales scores. That was differed from other previous studies, which reported low rates of ADHD, as these studies used clinic referred samples, the diversity of definitions used to diagnose RD has resulted in inconsistent reports of the comorbidity between ADHD and RD [6]. In addition, the higher rate of our results was returned to more accurate diagnosis as we used of 4 scales (QNST, Hasan Shehata Reading scale, Ahmed AWD reading scale and comprehension scales) for determining dyslexia incidence. Also we used two diagnostic scales to determined ADHD.

That association between ADHD and dyslexia could be attributed to strong influenced by genetic factors upon each disorder [30-32]. Results of candidate gene and linkage studies of reading disabilities and ADHD have suggested the presence of common genes that contribute to both disorders [33]. There is no additional evidence to support that the 2 disorders are transmitted independently in families [34,35]. These findings suggest that both reading disability and ADHD are disorders based, at least in part, on common genetic etiologic factors that increase susceptibility to the comorbidity of both disorders [5].

5. CONCLUSION

The results of this study indicate that cognitive functions and psychomotor performance were impaired among dyslexic students than control group. Also, the prevalence of ADHD is significantly higher in students with dyslexia. More deterioration of dyslexic symptoms associated with more deterioration in some cognitive functions and psychomotor performance.

6. LIMITATION OF STUDY

Small sized sample was used in this study. We could attributed that as we surveyed 200 students from all first class of one preparatory school in Assuit city only as time limited.

CONSENT

All authors declare that written informed consent was obtained from the patient (or other approved parties).

ETHICAL APPROVAL

All authors declare that all patients and control groups have been examined and approved by the local ethical committee of Assiut University, faculties of Medicine and Art approved the study. This study was in agreement with Helsinki declaration research ethics.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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